AFRL-SN-WP-TP-2005-114

NARROWBAND MID-INFRARED GENERATION IN ELLIPTICALLY PUMPED PERIODICALLY POLED LITHIUM NIOBATE

Peter E. Powers, Prasanth K. Bojja, Eric Vershure, and Kenneth L. Schepler

FEBRUARY 2003

Approved for public release; distribution is unlimited.

STINFO INTERIM REPORT

SENSORS DIRECTORATE
AIR FORCE RESEARCH LABORATORY
AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7320

NOTICE

/s/
Kenneth L. Schepler
Principal Scientist
EOCM Technology Branch

/s/
William R. Taylor, Acting Chief
EOCM Technology Branch
EO Sensors Technology Division

/s/
ROBERT D. GAUDETT, Colonel, USAF
Chief, EO Sensor Technology Division
Sensors Directorate

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE ***(DD-MM-YY)***	**2. REPORT TYPE**	**3. DATES COVERED** ***(From - To)***
February 2003	Conference Paper Postprint	03/01/2002 – 11/01/2002

4. TITLE AND SUBTITLE

NARROWBAND MID-INFRARED GENERATION IN ELLIPTICALLY PUMPED PERIODICALLY POLED LITHIUM NIOBATE

5a. CONTRACT NUMBER
In-house

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
61102F

6. AUTHOR(S)

Peter E. Powers, Prasanth K. Bojja, Eric Vershure (University of Dayton)
Kenneth L. Schepler (AFRL/SNJW)

5d. PROJECT NUMBER
2301

5e. TASK NUMBER
EL

5f. WORK UNIT NUMBER
01

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

University of Dayton Center for Electro Optics 300 College Park Dayton, OH 45469-2314	Electro-Optical Countermeasures Technology Branch (AFRL/SNJW) Electro-Optical Sensors Technology Division Sensors Directorate Air Force Research Laboratory, Air Force Materiel Command Wright-Patterson Air Force Base, OH 45433-7320

8. PERFORMING ORGANIZATION REPORT NUMBER
AFRL-SN-WP-TP-2005-114

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Sensors Directorate
Air Force Research Laboratory
Air Force Materiel Command
Wright-Patterson AFB, OH 45433-7320

10. SPONSORING/MONITORING AGENCY ACRONYM(S)
AFRL/SNJW

11. SPONSORING/MONITORING AGENCY REPORT NUMBER(S)
AFRL-SN-WP-TP-2005-114

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

Published in CLEO (Conference on Lasers and Electro-Optics) Summaries, 2003, Optical Society of America.

14. ABSTRACT

Narrow bandwidths and near diffraction limited beam divergence are demonstrated in an elliptically pumped, diode-laser seeded, optical parametric generator. This represents a significant step towards high-energy tunable infrared systems with favorable beam characteristics.

15. SUBJECT TERMS

Laser, infrared, narrow bandwidth, optical parametric generator, periodically poled lithium niobate

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT:**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** (Monitor)
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Kenneth L. Schepler
Unclassified	Unclassified	Unclassified	SAR	8	**19b. TELEPHONE NUMBER** *(Include Area Code)* (937) 904-9661

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18

Narrowband mid-infrared generation in elliptically pumped periodically poled lithium niobate

Peter E. Powers, Prasanth K. Bojja, and Eric M. Vershure
Center for Electro Optics, University of Dayton, 300 College Park, Dayton OH 45469-2314
peter.powers@notes.udayton.edu

Kenneth L. Schepler
Air Force Research Laboratory, AFRL/SNJW, Bldg 622, WPAFB OH 45433-7706

Abstract: Narrow bandwidths and near diffraction limited beam divergence are demonstrated in an elliptically pumped, diode-laser seeded, optical parametric generator. This represents a significant step towards high-energy tunable infrared systems with favorable beam characteristics.

OCIS codes: (190.4360) Nonlinear optics, devices

We report on a method to control both the bandwidth and the divergence of elliptically-pumped optical parametric generation devices (OPG's) using a diode laser seeding scheme. This source has important applications such as in environmental sensing where propagating a beam over long distances is required, and where narrow bandwidth is required for chemical species selectivity. Previous work with high-energy OPG's has shown that elliptical pumping is a viable means of scaling up the energy of OPG devices [1]. However, the use of large aperture pump beams increases the size of the gain channel in the material for a given OPG interaction. This, in turn, allows multiple noncollinear processes to see gain throughout the length of the material in addition to collinear processes. To mitigate these effects, periodically poled lithium niobate (PPLN) crystals were poled with several separated gratings that had the effect of limiting the noncollinear interactions. Even so, the collinear bandwidth for such devices is still large and the beam divergence is that of a single one of the gratings. In the present work we use a diode laser co-aligned with the pump laser to act as a spectral and spatial seed. The favorable narrowband and diffraction-limited beam properties of the seed beam are shown to be transferred to the OPG output.

To demonstrate this experimentally the pump beam was supplied by a Q-switched Nd:YAG laser operating at 10 Hz with 3.5-ns pulses. The operating wavelength was 1.064 μm and the energy was 6 mJ. The laser beam profile was a "top hat," and this was relay imaged onto a 30-cm focal length cylindrical lens. The cylindrical lens focused the laser into a 3.2 mm x 200 μm (diameter) cross section. The pump beam was aligned through a 29.75-μm periodicity PPLN crystal. The PPLN aperture was 5 mm x 0.5 mm, and its length was 30 mm. A cw-diode laser was co-aligned with the pump to have a slightly larger ellipticity to ensure overlap with the pump. The power of the cw diode laser was varied up to 9 mW incident on the crystal..

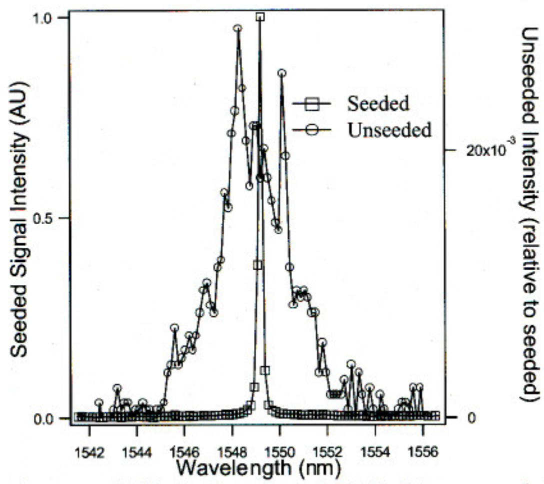

Fig. 1. Seeded and unseeded output of elliptically pumped OPG. Note unseeded intensity references the right ordinate axis and is much lower in intensity than the seeded bandwidth.

Figure 1 shows the output signal bandwidth of the OPG with and without seeding. It is clear from the figure that seeding significantly reduced the bandwidth. The bandwidth is less than 1 cm^{-1}, limited by the resolution of the monochromator. The energy in the signal and idler beams was measured to be 0.7 mJ when pumping with 8 mJ, and seeding with 9 mW. The threshold for effective seeding was 0.5 mW incident on the crystal. The far-field beam profile of the idler when seeded and unseeded was measured with an infrared camera, and is shown in figure 2. Figure 2 (a) shows that the beam divergence is nearly equal in the vertical and horizontal directions for the unseeded idler. This indicates that the beam is far from diffraction limited and can be attributed to multiple noncollinear processes that see significant gain. Because of the elliptical beam shape in the crystal, a diffraction-limited beam would be highly asymmetric in the far field. A diffraction-limited beam should have a large divergence in the vertical direction where the elliptical beam is small and it should have a small divergence in the other direction. Figure 2 (b) shows that when the signal beam is seeded, the idler takes on the expected beam shape in the far field of a diffraction limited beam. Note that two distinct beams can easily be seen. The crystal, AR coated for the pump and signal, was not AR coated for the idler. This gives rise to an etalon effect, and coupled with a slightly wedged crystal gives rise to multiple idler outputs. The divergence of the idler when seeded is 1.9 mrad (FWHM) in the narrow direction, which is 1.5 times diffraction limited. This, when compared to the 29-mrad divergence of the idler when not seeded shows a great improvement in beam quality.

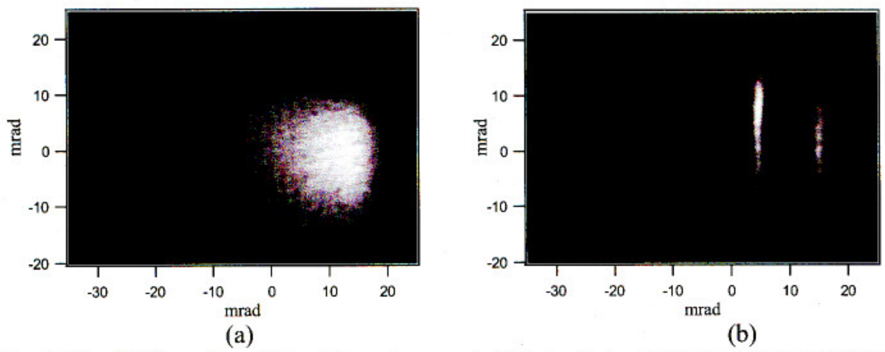

Fig. 2. Far-field profile of the idler: a) unseeded b) seeded. Note that the seeded profile required higher attenuation in front of the camera to avoid saturation.

In conclusion, we demonstrate a viable path to generating high-energy and narrow-bandwidth in the mid-IR with a simple system. This will have an impact on laser remote sensing applications that require high energy and good beam characteristics.

---

1 S. M. Russell, P. E. Powers, M. J. Missey, K. L. Schepler, "Broadband mid-infrared generation with two-dimensional quasi-phase-matched structures," IEEE Journal of Quantum Electronics **37**,877-887 (2001).